

Chapter 11

Historical Perspectives on Forests of the Sierra Nevada and the Transverse Ranges of Southern California: Forest Conditions at the Turn of the Century

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Preface

Let me say a word of thanks to the members of the forestry force who acted as my escort. I wish to thank other gentlemen also, but particularly the members of the forestry force. I am, as you gentlemen probably know, exceedingly interested in the question of forest preservation. I think our people are growing more and more to understand that in reference to the forests and the wild creatures of the wilderness our aim should be not to destroy them simply for the selfish pleasure of one generation, but to keep them for our children and our children's children. I wish you, the Forest Rangers and also all the others, to protect the game and wild creatures and of course in California, where the water supply is a matter of such vital moment, the preservation of the forests for the merely utilitarian side is of the utmost, of the highest possible consequence; and there are no members of our body politic who are doing better work than those who are engaged in the preservation of the forests, keeping nature as it is for the sake of its use and of its beauty.

Theodore Roosevelt, 9 May 1903.

The Sierra Nevada has been impacted by western civilization for more than 150 years and heavily impacted for at least the past 100 years. Impacts include mining, logging, the grazing by both sheep and cattle, and changes in fire patterns—notably fire suppression in the twentieth century. Site-specific data from the 1800s are scattered and not comprehensive, but several events occurred around the turn of the century that led to reasonably detailed and quantitative accounts of the condition of the land and forests. General Grant, Sequoia, and Yosemite National Parks (NPs) were established in 1890. Forest reserves were set aside between 1891 and 1909 and renamed as National Forests (NFs) in 1907. After creation of the forest reserve system, the United States Geologic Survey (USGS) initiated the first systematic surveys of the forest reserves as part of a series of annual reports. For a brief period, from about 1897 to 1902, these surveys were very thorough and often included maps of topography, timber volume, logging intensity, and species distribution. Surveys covering most of what is now the Eldorado and Stanislaus NFs and Yosemite NP were published in 1900 (Fitch 1900a, 1900b; Marshall 1900; Sudworth 1900a). Similar inventories were done by Leiberg (1902), mainly in what is now the Tahoe and Plumas NFs. Additional information concerning what are now the Sierra and Sequoia NFs and Sequoia/Kings Canyon NPs was obtained by analyzing Sudworth's (1900b) unpublished field notes.

Areas in southern California were also surveyed around the turn of the century. Leiberg (1899a, 1899b, 1899c) examined the

San Jacinto, San Bernardino, and San Gabriel reserves in 1897. The San Jacinto Quadrangle was reexamined in 1900 and Barnard (1900) produced a 30-minute topographic map (fig. 11A).

This chapter is largely an analysis of these USGS survey efforts, with ancillary data from other sources. The men involved with the surveys were professionals whose job it was to assess the condition of the newly created reserves. Their studies appear to be reliable and accurate, providing quantitative assessments of forest stands that are of great historic interest and importance today.

Sierran Forests at the Turn of the Century

Nonaboriginal Human Impacts

Logging in the Middle and Southern Sierra Nevada

Logging was used mainly to support local markets, including the growing towns and communities of the Sacramento and San Joaquin Valleys (Ayers 1958). All major towns were associated with mines, and nearly all timber cut supported the mines—for housing employees, timbers to keep tunnels from collapsing, processing ore, and transporting processed ore to market by rail (Sudworth 1900a). "Large mines" consumed between 2,000 and 3,500 cords annually (fig. 11B). Fuel needs of stamp mills—machines or mills for pulverizing ore—were impressive. The Empire Mine, for instance, had a 30-stamp mill that consumed 11 cords of wood in a 10-hour period (Bohakel 1968) or, assuming constant operation, 9,600 cords a year.

Most logging before 1900 occurred at low elevations on lands adjacent to mines, because wagons were the chief means for transporting timber (Sudworth 1900a, Leiberg 1902) (fig. 11C). Sudworth mapped cut-over and partially cut regions (fig. 11D, table 11A). With the exception of a large area of cutting that extended up the American River, Forest Service (FS) lands and many higher-elevation private lands had not been logged (fig. 11E). Laudenslayer and Darr (1990) provided an analysis of cutting during that period by the Michigan-California Timber Company.

The partially cut lands, especially those more distant from Placerville, were largely exploited for the shake market (Sudworth

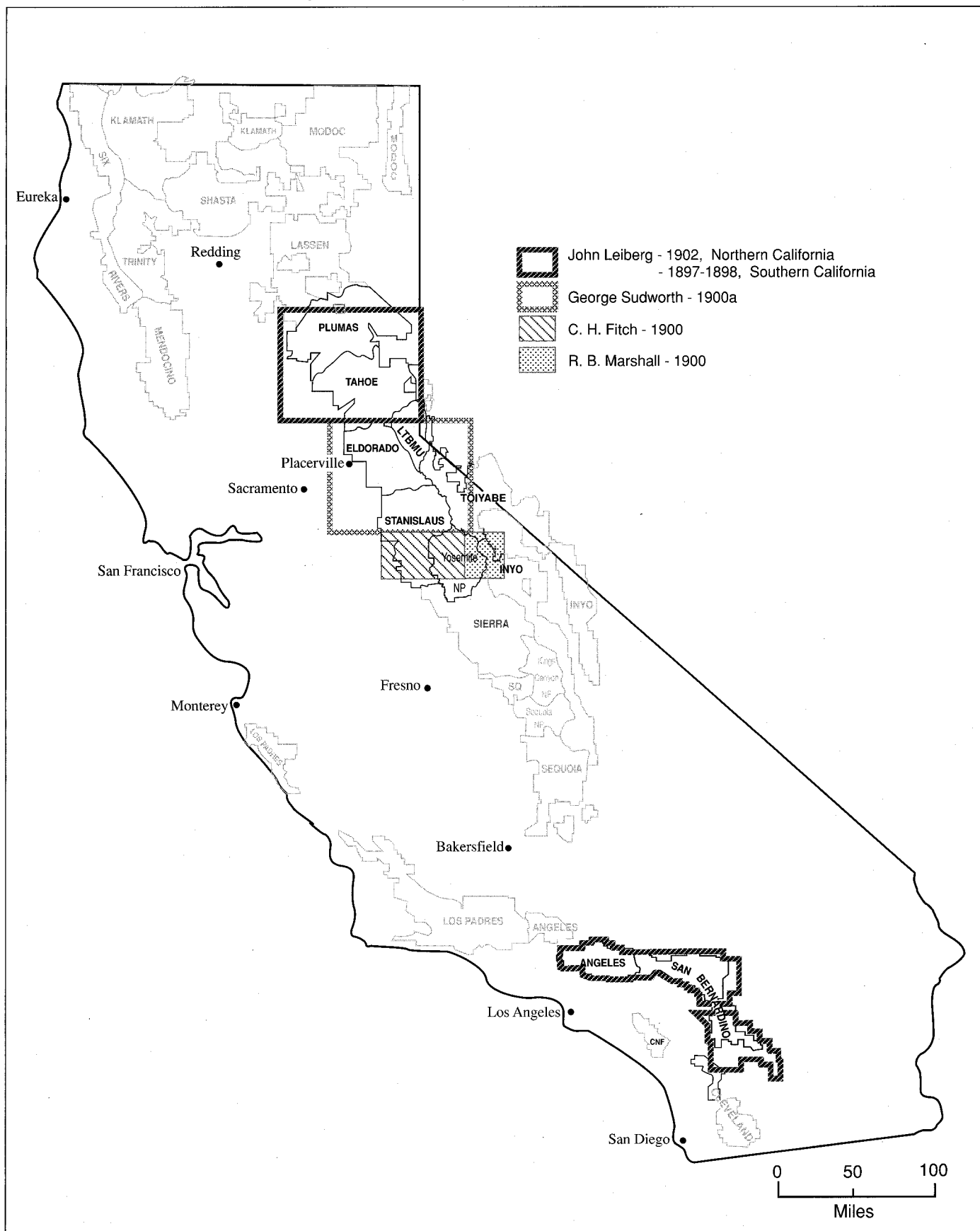


Figure 11A--Areas surveyed by Leiberger (1899a, 1899b, 1899c, 1902), Marshall (1900), Fitch (1900a, 1900b), and Sudworth (1900a).

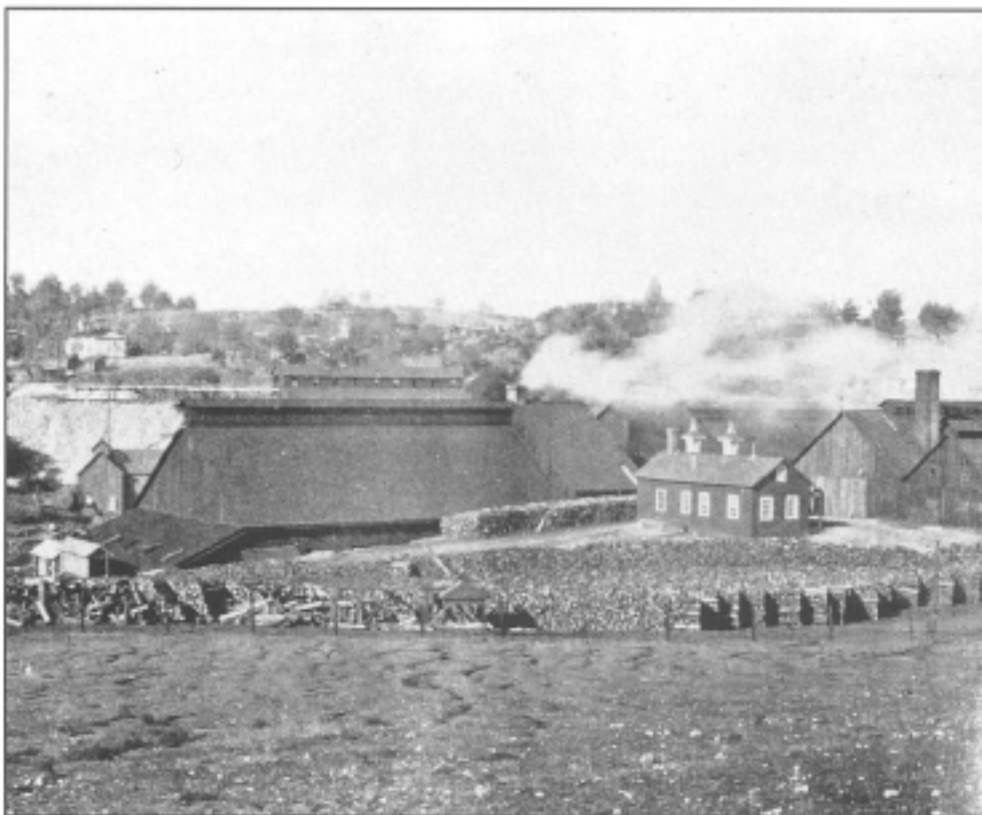


Figure 11B--Large mining plant at Angels Camp, where great quantities of yellow pine cord wood were consumed. Thousands of cords of this 4-foot cordwood were needed to keep each mill going throughout the year. Hundreds of mills operated up and down the Sierra Nevada during this era, processing ore for gold and other minerals. Wood also was the primary fuel for heating and cooking in homes and businesses, as well as providing energy to run the steam engines, which powered winches, sawmills, and locomotives.

Location: -----In foothills just below the Stanislaus National Forest, central Sierra Nevada.

Elevation:-----About 2,000 feet

Date: -----Probably 1899

Source:-----Sudworth 1990a

Photo-grapher: ----Unknown

Figure 11C--A common method of hauling yellow pine logs to mills was by horse and wagon. Before railroads entered the area, transportation of raw logs and lumber had definite limitations. Mills, which remained close to the timber source, tended to be smaller and more mobile. When the local timber was used up, the mill was disassembled and moved to another area.

Location:-----Stanislaus National Forest, central Sierra Nevada

Elevation: ----About 4,000 feet

Date: -----Probably 1899

Source: -----Sudworth 1990a

Photo-grapher: ----Unknown



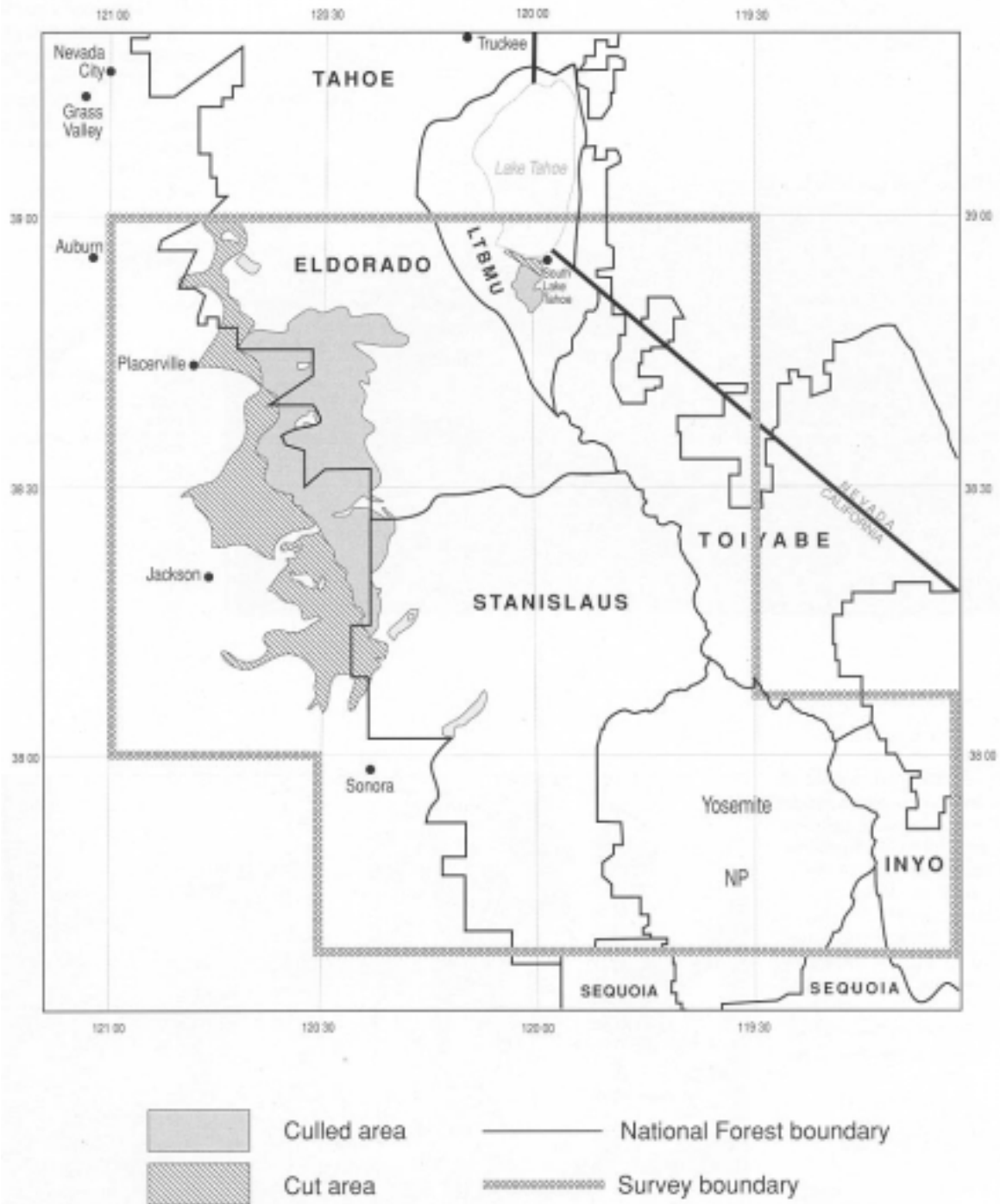


Figure 11D--Areas of logging activity from maps by Marshall (1900), Fitch (1900a), and Sudworth (1900a). Culled areas were selectively logged. Most of the cutting in this area was associated with the town of Placerville.

Table 11A--Areas sampled by Sudworth in the Sierra Nevada at the turn of this century (Sudworth 1900a) (see figs. 11A and 11D).

Areas	Area (square miles)		
	Logged	Culled ¹	Virgin ²
Thirty-minute quadrangles			
Placerville	122	162	152
Jackson	175	18	0
Pyramid Peak	0	148	642
Big Trees	89	104	564
Markleeville	0	0	322
Dardanelles	0	0	659
Forest Reserves			
Stanislaus	0	0	641
Tahoe	0	3	130
Total	386	435	3,190
Percent of total	10	11	79

¹ Culled areas were selectively logged.

² Lands listed as grazing or nonforest were omitted.

1900a). Shakes were the most valuable product at the time, maintaining a market value well above dimension lumber into the twentieth century. On the Stanislaus NF in 1912, for instance, shake prices were \$5.00 to \$7.50 per thousand (Graves 1912), approximately the same price reported by Sudworth.. Shakes were produced only from the choicest sugar pines, and only from select portions of the bole--no more than 40 percent, according to Sudworth. For this reason, shake cutting always resulted in partial removal of standing timber, and it always left much waste. Following a similar pattern, giant sequoias were split to produce grape-stakes (fig. 11F).

Logging in the Northern Sierra Nevada

Ore deposits extended into higher elevations in the northern Sierra Nevada than in the middle and southern parts. Consequently, placer and hard-rock mining and logging were more extensive there than to the south. In particular, areas north of Nevada City and the Truckee Basin were heavily cut (fig. 11G). Again, access was key and the presence of the Southern Pacific Railroad allowed transportation to more distant markets. Lake

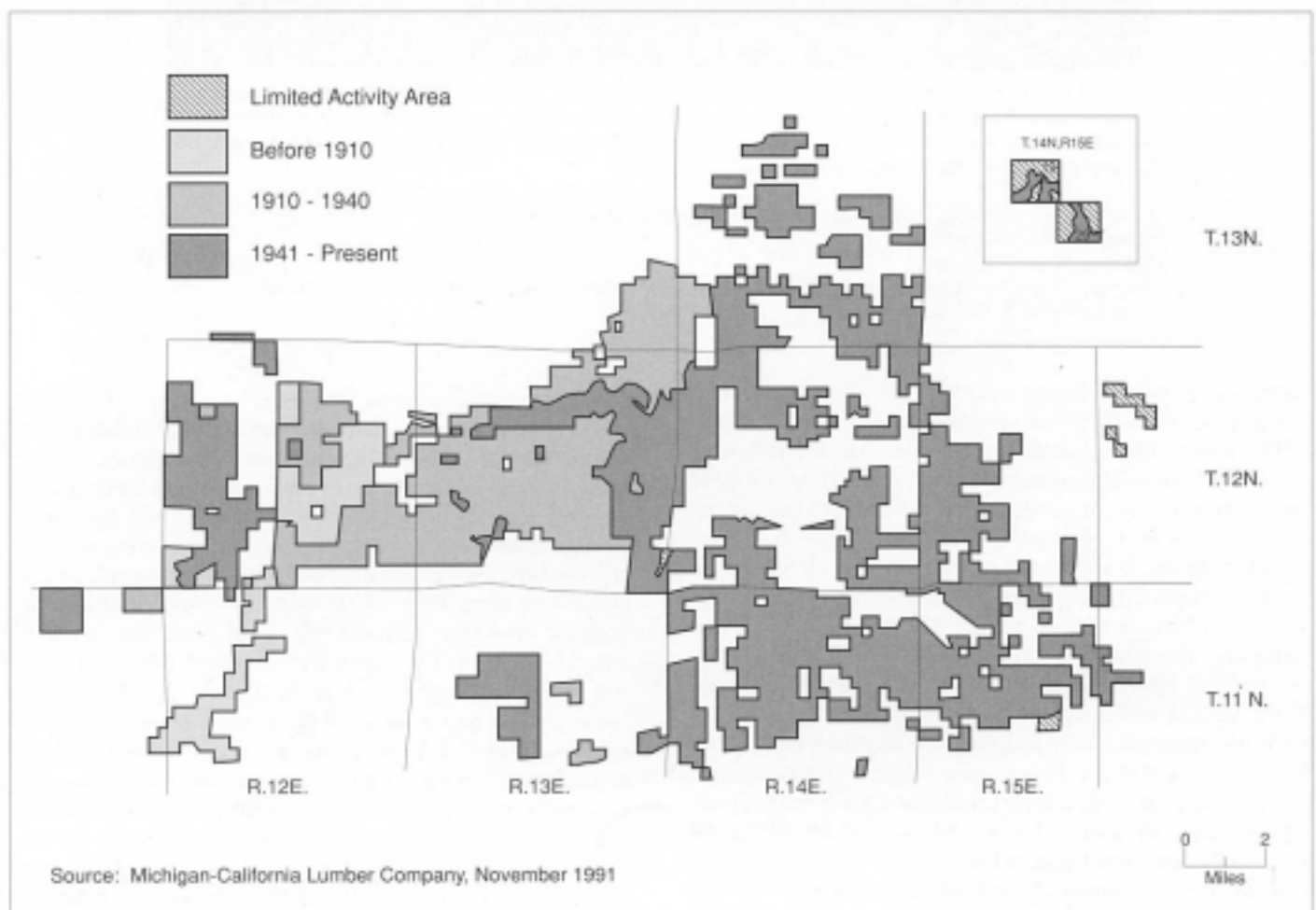


Figure 11E--Chronology of cutting on lands of the Michigan-California Timber Company. These lands lie within the area surveyed by Sudworth in 1900. Cutting prior to 1910 occurred within a very limited acreage.



Figure 11F--This ancient giant sequoia, named the Mark Twain Tree in 1888, sprouted in 550 A.D.; it was 1,341 years old and 90 feet around the base at the time of this photo. Smith Comstock erected a sawmill just 250 yards west of this tree. Giant sequoia wood made poor lumber, so it was split into grapestakes (center) and posts (left) to supply California's rapidly expanding vineyards.

Location: -----Big Stump, Sequoia/Kings Canyon National Parks

Elevation: -----5,760 feet

Date: -----1891

Source: -----Steve Anderson Collection, Hume Lake Ranger District, Sequoia National Forest

Photographer: -----C. C. Curtis

Tahoe also provided convenient access, allowing large quantities of timber to be taken from areas adjacent to the lake (Leiberg 1902, McKeon 1984). In addition, a 4-mile-wide strip following the railroad between Reno and Sacramento was heavily logged for locomotive fuel (fig. 11G; Palmer 1992). Gold-bearing deposits at mid-elevations (Clark 1966) caused mines to be scattered throughout forests of the region. The Yuba River Basin, north of Nevada City, was logged to supply large mines at Grass Valley and Nevada City (elevations 2,400 and 2,600 feet, respectively) as well as at Sierra City (elevation 4,200 feet).

Leiberg (1902) reported that 1,386,890 acres in the northern Sierra Nevada were logged between 1850 and 1902, and that 2,337,930 acres were uncut. Logging intensity there varied from 5 to 99 percent of total volume removed. Leiberg estimated that, on the average, only 50 percent of the volume was removed from logged stands. He provided two means to evaluate the spatial extent and intensity of logging. The maps used to prepare figure 11G gave volume estimates, both in the "culled" areas and in areas that were not entered. Those maps were supported by detailed written descriptions of the forest on a drainage-by-drainage basis.

Analysis of cutting patterns in the North and Middle Forks of the Feather River, for instance, clearly shows that most cutting occurred at elevations below current FS boundaries. Oroville was the primary destination of lumber from these drainages, and the only method for transporting the timber was by wagon, restricting the trip to 40 miles or less (Leiberg 1902). Most cut areas reported by Leiberg were within 20 miles, straight-line, of Oroville or along lower slopes adjacent to the Central Valley north of there. For example, Big Bend Mountain (about 15 miles) was heavily cut over and Chino Creek (about 20 miles) was reportedly logged. According to Leiberg (1902, p. 58), however, in an area of about 15 square miles immediately north of Chino Creek "...lies a block of heavy forest, the heaviest in the basin. It is of the yellow-pine type, but contains an unusually large proportion of sugar pine... Both the yellow and sugar pine in this heavy block of timber are of exceptionally large size and of old growth. Much of the sugar pine runs above 5 feet basal diameter, with clear trunks 40 to 60 feet in height." This block of timber was clearly desirable but just beyond reach of the wagon-based logging of 1902. For this reason, cutting in these

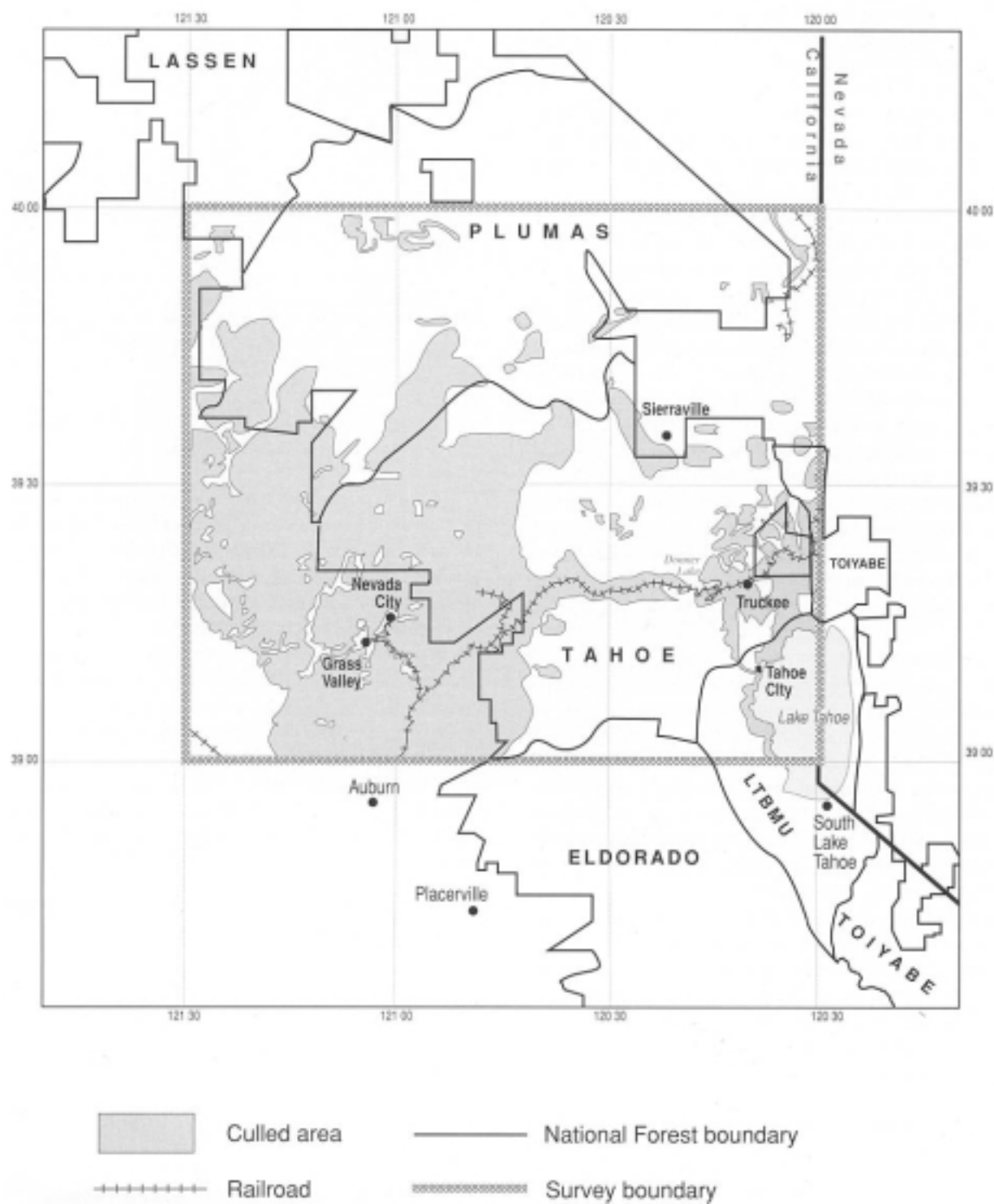


Figure 11G--Areas of logging activity from maps by Leiberg (1902). Leiberg did not, as did Sudworth (1900a), differentiate between cut-over lands and culled lands. In many areas cutting appears to have been very light.

drainages did not extend far into what is now the Plumas NF (fig. 11G). Areas of NF land that were entered tended to be at extreme limits of the transportation capabilities and would therefore have been subjected primarily to high-grading of sugar pines. This assertion is supported by an inventory done by the Plumas NF in 1910, which estimated that 870,506 acres of the Plumas were in a forested condition but only 11,983 acres (1.3 percent) had been "cut over" (Moore 1913).

On the other hand, 57 percent of the Yuba river drainage was described as being cut. In areas adjacent to towns or major rivers, Leiberg stated that most trees were removed. On other lands, cutting was much more selective.

Results of inventories by Leiberg and Sudworth, supported by the Plumas NF plan of 1913 and records of the Michigan-California Timber Company, show that cutting at the turn of the century was spatially limited to areas near population centers and major transportation routes. With notable exceptions of the Truckee Basin, Yuba River Basin, and lands immediately adjacent to the Southern Pacific Railroad, logging occurred at low elevations with relatively little within NF boundaries in the Sierra Nevada prior to the turn of this century. Limited by transportation capabilities, much of the logging on what are now NF lands was reduced to light high-grading of the most valuable trees. The NF most heavily impacted was the Tahoe. There the railroad, combined with mining at higher elevations, caused significant logging in what is now FS land. Even in the Tahoe NF, however, about half of the forest had not been entered at the turn of the century.

Grazing by Sheep

Unlike logging, which impacted limited acreage in the Sierra Nevada prior to 1900, the entire Sierran range appears to have been intensely overgrazed for decades, beginning in the early 1860s when a severe drought killed most of the cattle in California (Vankat 1970, Ratliff 1985, Ewing et al. 1988). According to Ratliff, not only did the drought cause a shift from cattle to sheep, but it also initiated the practice of summer grazing in alpine meadows of the Sierra Nevada (fig. 11H). In 1862, California ranges supported 3 million sheep, about 40 percent of which grazed the Central Valley. Grazing peaked in 1876, when more than 6 million sheep grazed state-wide (Ratliff 1985, Ewing et al. 1988). Sheep grazing was still intense in 1900, when an estimated 200,000 animals grazed during summer and fall in the Sierra Reserve (Vankat 1970). Descriptions of the impact of grazing on vegetation are particularly intense in much of the literature of that period:

There are practically no grasses or other herbaceous plants. The forest floor is clean. The writer can attest the inconvenience of this total lack of grass forage for in traveling over nearly 3,000,000 acres not a single day's feed for saddle and pack animals was secured on the open range... Barrenness is, however, not an original sin. From a study of long-protected forest land in the same region and from the statements of old settlers, it is evident that formerly there was an abundance of perennial forage grasses throughout the forests of this territory... It would seem that this bare condition of the surface in the open range has been produced only through years of excessive grazing by millions of sheep--a constant overstocking of the range (Sudworth 1900a, p. 554-555).

The trampling of thousands of sheep pastured on these slopes during the summer and fall reduces the soil, to a depth of 6 or 8 inches, to the consistency of dust. Rain washes this dust into creeks and rivers, and heavy winds lift it up and carry it away (Leiberg 1902, p. 15, concerning the red fir type).

The great obstacle to the explorer is not the danger of crag or chasm, but the starvation threatening his animals, through the destruction of the fine natural meadow pasturage by sheep (Russell Dudley 1898, professor of botany, as quoted by Vankat 1970, p. 20).

The soil being denuded of grass is broken up by thousands of sheep tracks, and when the rains come this loose soil is washed down the mountainsides into the valleys, covering up the swamps and meadows, destroying these natural reservoirs (1894 report by Acting Superintendent of Sequoia and General Grant NPs, as quoted by Vankat 1970, p. 20).

The Kern River drainage was ...almost impassable to the traveler, to such an extent is every living thing eaten off the face of the earth and trampled underfoot by the hundreds of thousands of sheep which each year roam over that territory (1893 report by Acting Superintendent of Sequoia and General Grant NPs, as quoted by Vankat 1970, p. 29).

Clean surface; sheep grazed and burned. No reproduction. 10,000 feet elevation (Sudworth 1900b, p. 10).

The last quote above, referring to an area at the headwaters of the Kings River, now in Sequoia/Kings Canyon NPs, was typical of site-specific examples in Sudworth's notes. The seasonal migration of sheep from the Central Valley up to alpine meadows in mid-summer meant that even very remote locations experienced the impact of overgrazing.

Recurrent themes typify the writings of different observers. Grazing at an intensity that produced significant soil erosion was noted in both the northern and southern Sierra. Removal of all grass was repeatedly mentioned in the context of travel being inconvenient because pack animals could not graze. In many cases, this was contrasted with the contention that grasses were abundant in forests prior to grazing. Although we suspect that many early writers harbored an anti-sheep bias, the numbers of sheep mentioned casually (hundreds of thousands, millions) appear to be accurate.

Burning by Sheep Herders

Sheep herders also burned extensively to encourage growth of grasses and forbs and to remove fuel and young trees from the forest floor. All accounts mention this, but we cannot be certain about the extent to which sheep-related fires contributed to overall fire frequency. John Muir, writing in 1877, felt that 90 percent of fires were caused by sheep herders, but his estimate was probably exaggerated (Vankat 1970). It is clear, however, that the pattern and intent of fires set by sheep herders differed from those set by Native Americans. The intent was to improve grazing on high-altitude pasturage and to remove obstacles that impeded movement by sheep. Consequently, sheep herders gave special attention to burning large, downed fuels (Sudworth 1900a, Vankat 1970) and to burning mesic areas to stimulate forage production.

We consider it likely that this intensity of grazing, combined with repeated burning by sheep herders, had a severe impact on herbaceous vegetation and on patterns of forest regeneration in the



Figure 11H--Sheep grazing in the Sierra Nevada.

Location: -----Northside of Crabtree Meadow, Sequoia National Park

Elevation: -----10,400 feet

Date: -----29 July 1890

Source:-----Vankat (1970) Photographer: -----Unknown

Sierra Nevada. In the absence of competing vegetation, regeneration was rapid and dense when sheep and fires ignited by sheep herders were no longer prevalent in montane forests. According to Leiberger (1902, p. 15), such areas were common

...varying from 1 acre to 3 or 4 acres, scattered along the ridges from Webber Peak to the Rubicon River, on which the grass and weeds have been so thoroughly eaten out that even the sheep have abandoned them. On such tracts, left undisturbed for four or five years, Shasta firs [red fir] cover the ground to the number of 10,000 to 15,000 trees to the acre.

Leiberger (1902, p. 43) also reported that stands freed from burning for 15 years

...may be seen in the Mohawk Valley, on areas in the central portions of the basin of the West Fork of Feather River and in the northern portion of the Truckee Basin. These sapling stands, composed of yellow pine, red [Douglas-] and white fir, and incense cedar, singly or combined, are so dense that a man can with difficulty force his way through.

Sudworth (1900a, p. 553) found a "general lack of herbaceous growth and irregular reproduction of timber species [and a] general absence of small-sized timber intermediate between seedlings and the large timber" in unfenced forests. In "fenced and otherwise protected forests," he found "uniform abundance of herbaceous growth," "plentiful reproduction of timber species," and "presence of intermediate sizes of small timber."

Vankat (1970) measured the ages of numerous trees in Sequoia NP, finding that a major regeneration pulse occurred at approximately the time sheep were removed from the Park (fig. 11I). Vankat also found that particular areas (for example, meadows) and species (for example, big sagebrush) had not recovered from grazing by the late 1960s. We can reasonably infer that the intensity of sheep grazing for nearly 40 years in the Sierra Nevada impacted stand structure and regeneration patterns, producing lasting changes in mixed communities of grasses, forbs, and shrubs.

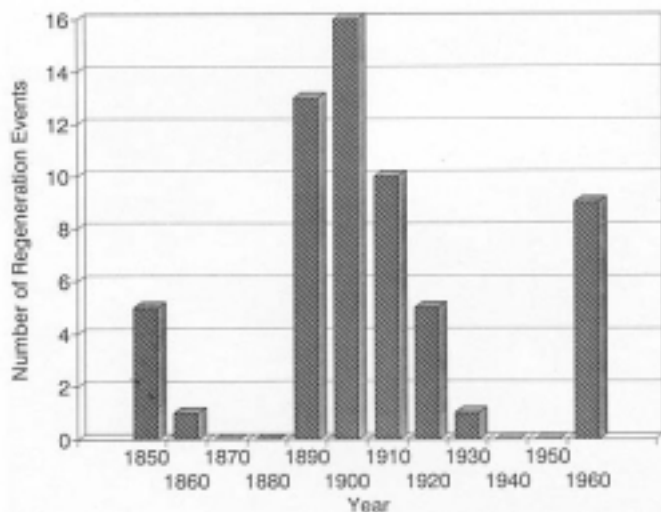


Figure 11I--Periods of significant regeneration on sites within Sequoia National Park. This graph was generated by combining tables found in the appendices of Vankat (1970).

Stand Structure

The best data on stand structures at the turn of this century came from a set of 1/4-acre plots measured by Sudworth (1900a, 1900b). Data from 22 plots were presented in his formal document (1900a) for the USGS on the Stanislaus and Tahoe reserves, and data from 26 additional plots were included in his notes on the Sierra Reserve (1900b). Here we report analyses of all plots in the USGS report but only 20 of the 26 plots in Sudworth's notes. Four of those not analyzed were in groves of giant sequoias (Sudworth was particularly interested in the big trees), and two were at high elevation and contained large components of foxtail pine. These plots represented uncommon forest types and were not considered of general interest. Sudworth did not describe the methods he used to select plots, but their primary purpose was to support the maps he created. His maps, a standard product in USGS surveys of that period, subdivided the entire area surveyed (about 3,000,000 acres) into subunits based on similarity in timber volumes. Sudworth often referred to his plots as being "representative" of a particular area. He probably used scattered plots to calibrate ocular estimates. He reported only trees 11 inches or more in diameter at breast height (d.b.h.) in the USGS report and only 12 inches or more in d.b.h. in his notes. He mentioned regeneration in his notes, but the meaning of the term was not quantified.

Several uncertainties are associated with analyses of data from the turn of the century. In particular, estimates of volume per acre, either at the stand level or derived from plot data, should be viewed with caution. At a stand level, volumes were calculated using scaling rules based on the limits of merchantability. Because small trees (for some species defined as trees <16 in d.b.h.) and tops were not used, and because saw kerfs were wider than today, the volume reported on a per-acre basis in 1900 would, therefore, be considerably less than if the same acreage were cruised today. This underestimation (by current standards) was significant. For the San Jacinto Reserve, for instance, Leiberg (1899a, p. 356) estimated the total volume at

98 million board feet (MMBF). He noted, however, that "The sawmills in the reserve... handle the timber in the most economical manner possible, utilizing the trees far up in the crown, where the diameter dwindles to 8 inches or less. Worked up in this manner, the quantity of available merchantable timber would amount to at least 200,000,000 feet..."--a full doubling of the volume estimate.

Volume estimates based on the plots could be derived directly from the data, but this too is risky because the criteria used for plot selection are unknown, and volume appears to have been very heterogeneously distributed in the forest. Fitch (1900a) noted that volume averaged 80-140 thousand board feet (MBF) per acre in selected areas of the Yosemite Quadrangle, but the overall average was between 30 and 40 MBF. Given the small number of plots available for analysis, coupled with the highly variable stocking levels present at the time, use of volume statistics derived from plot data to infer volume-per-acre for the forest system is not justified. For this reason, we have not used volume estimates to compare current and historical forest conditions. Instead we have used the proportions of stems in particular diameter classes, or the proportions of basal area by species.

Diameter Distribution

Stands described by Sudworth (1900a) were very large and very old. The average yellow pine, for instance, was reportedly 150-180 feet tall, 3-4 feet in d.b.h., and 250-350 years old. Although Sudworth did not measure trees less than 11 inches in d.b.h., available evidence indicates that trees in those smaller classes were uncommon, though patches of very small regeneration appear to have been present, based on photos and text in Sudworth's report and on discussion by Leiberg (1902) of regeneration following removal of sheep. Most stems exceeded 25 inches in d.b.h., and many extremely large specimens were measured (fig. 11J). Of the major timber species, sugar pine, Douglas-fir, and white fir occurred only as very large trees (fig. 11K). Sugar pines were a minor stand component, but most of them were in the very large diameter classes. A comparison of that distribution with the largest diameter stands in Sierran for-

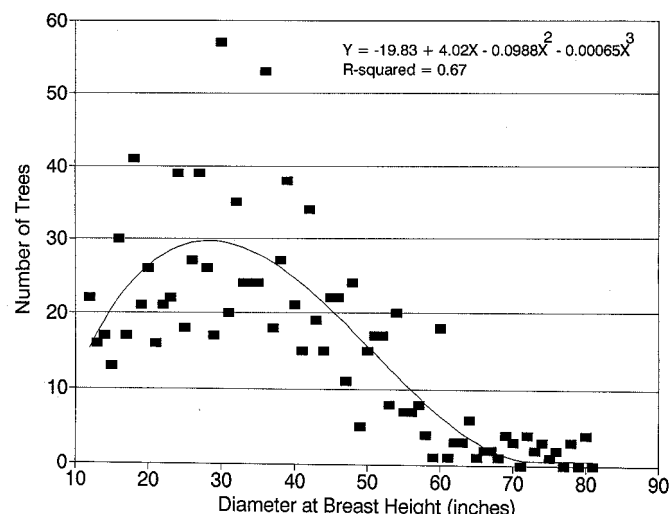


Figure 11J--Distribution of trees in forests of the Sierra Nevada in 1900. All species were lumped by diameter class and all of the plot information (Sudworth 1900a, 1900b) was combined. Many of the trees with diameters at breast height <15 inches were lodgepole pines.

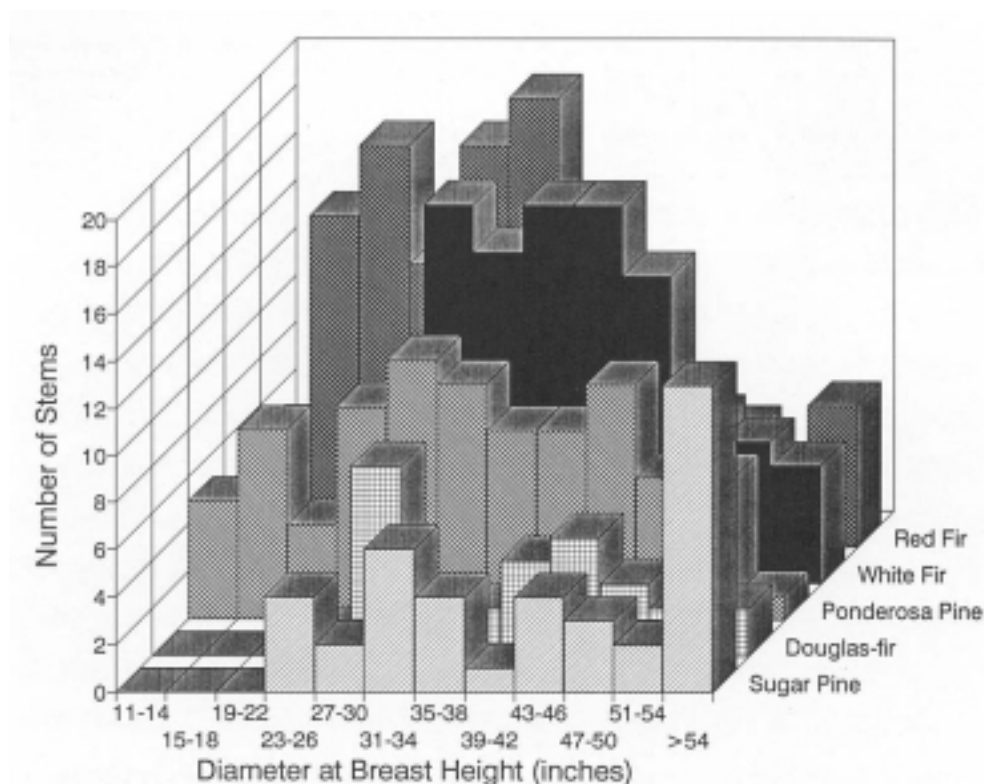


Figure 11K--Diameter distribution of trees in the Sierra Nevada, by species, for published plot data (Sudworth 1900a). Sugar pine, Douglas-fir, and white fir were present only in very large diameter classes.

ests today shows that far more of the stand basal area in the forests of 1900 was concentrated in very large trees (fig. 11L).

Species Composition

Species composition was apparently mixed at the turn of the century, with all major timber species represented. White fir and incense-cedar were widely distributed and present in large numbers (table 11B, fig. 11M). Pines did not dominate the forests, either in number or in volume. Volume estimates by species at about the turn of the century, available from several sources (table 11C), supported the plot-level data of Sudworth (1900a, 1900b). Note that many estimates made at that time underestimated the volume in true fir, because those trees were not considered merchantable unless they were at least 16 inches in d.b.h., whereas pines were merchantable when 12 inches or more in d.b.h. (Leiberg 1902). For his part, Sudworth did not give forest-wide volume estimates, but noted that the elevational range of white fir was between 3,800 and 7,500 feet, and that it formed 30-45 percent of the stand in areas where it was most abundant.

When compared with the current species composition in Sierran forests, the composition at the turn of the century was reasonably similar (compare fig. 11N and table 11C). Comparing the forest-wide estimates made by the Plumas NF in 1913 (Moore 1913) with current estimates from mixed-conifer timber strata (timber strata codes are defined in table 1C and in Appendix B), it appears that true fir and incense-cedar have increased and that pines have decreased (fig. 11O). This is probably an overestimate of the shift, however, because other strata, such as

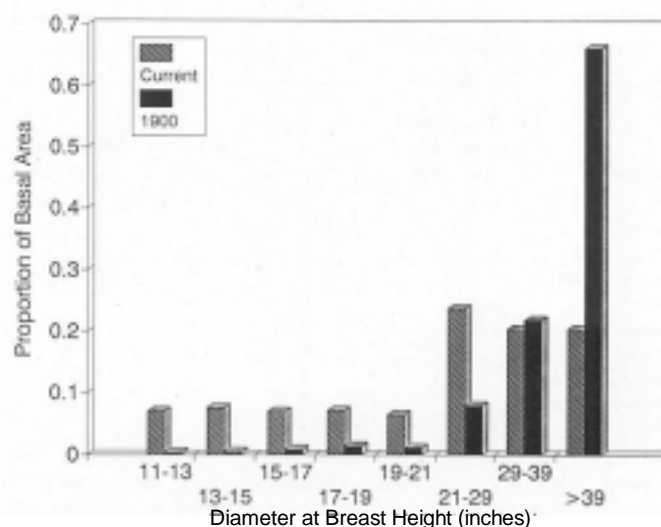


Figure 11L--Basal-area distributions of trees in forests of the Sierra Nevada for 1900 and current stands. The 1900 distribution was based on information presented in figure 11J; the current distribution was based on Forest Service Region 5 inventory data from timber strata for the largest size-classes (4, 5, and 6).

Table 11B—Species composition matrix (stems per quarter acre) for Sierran forests in 1900 (data from Sudworth (1900a)). Timber strata are our professional judgments about which current classes Sudworth's plots fit (E = eastside pine; M = mixed-conifer; P = ponderosa pine; W = white fir; R = red fir; L = lodgepole pine).

Plot	Sugar pine	Ponderosa pine	Western white pine	Lodgepole pine	Jeffrey pine	Incense-cedar	White fir	Red fir	Douglas-fir	Black oak	Mountain hemlock	Total	Timber strata
1					6		15					21	E
2	2	2				11	3					18	M
3		19				4						23	P
4	16					2	5					23	M
5		8				12				7		27	P
6							20	11				31	W
7				14								14	L
8	4					4	8					16	M
9								47				47	R
10	2				1	3	20	4				30	M
11					9							9	E
12			11					41			15	67	R
13					10		8					18	E
14	4				3	5	4					16	M
15	2					2	6		13			23	M
16			4	28				16				48	R
17	3	4				3	15		2			27	M
18	4	19				6				1		30	P
19		4				2			7	2		15	M
20	1	17				9				1		28	P
21		13				5						18	P
22	1					5	3		12			21	M
Total	39	86	15	42	29	73	107	119	34	11	15	570	
Percent	6.8	15.1	2.6	7.4	5.1	12.8	18.8	20.9	6.0	1.9	2.6		
Frequency	0.46	0.36	0.09	0.09	0.23	0.64	0.50	0.23	0.18	0.18	0.05		

Table 11C—Estimates of the proportional volumes of conifers at various times and locations in the Sierra Nevada.

Species	Yellow pine ¹ type, turn of this century	Shasta fir type, turn of this century	Plumas NF, 1913	M4G strata, ² 1980-1990
Sugar pine	20	0	16	12
Yellow pine	38	21	39	15
Incense-cedar	0	0	29	13
Douglas-fir	21	0	14	16
White fir	19	0	24	44
Red fir	12	75	18	0
Western white pine	0	3	0	0
Mountain hemlock	0	2	0	0

¹ Yellow pine and Shasta fir types from Leiberg (1902). These data were for standing "mill timber" cruised using "Michigan practice"—trees >8 inches in d.b.h. and having ≥10 feet of clear lumber in the trunk. Both incense-cedar and lodgepole pine were listed as being present in the stands, but they were not included in the mill estimates of timber volume. "Yellow pine" is either Jeffrey or ponderosa pine.

² Values shown for M4G strata were averaged over all Sierran National Forests. M4G strata were mixed-conifer stands, with trees ≥24 inches in diameter at breast height, and >69 percent canopy closure (see table 1C).

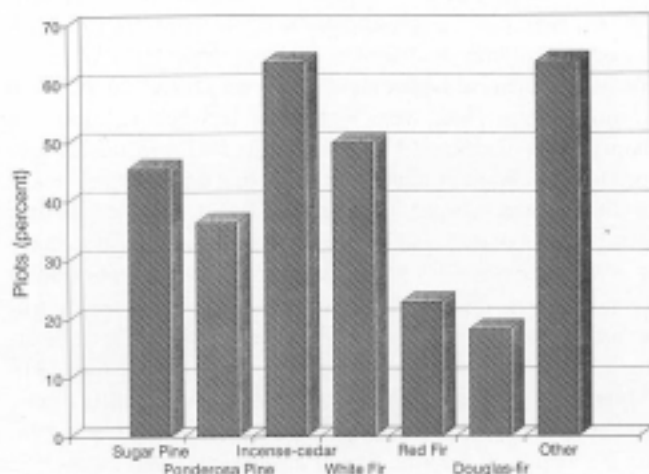
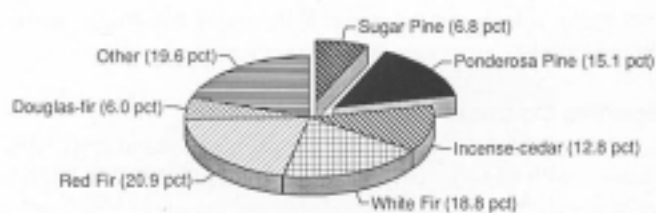


Figure 11M—Proportions of individuals and frequencies of occurrence among plots of tree species, based on plot data from Sudworth (1900a).

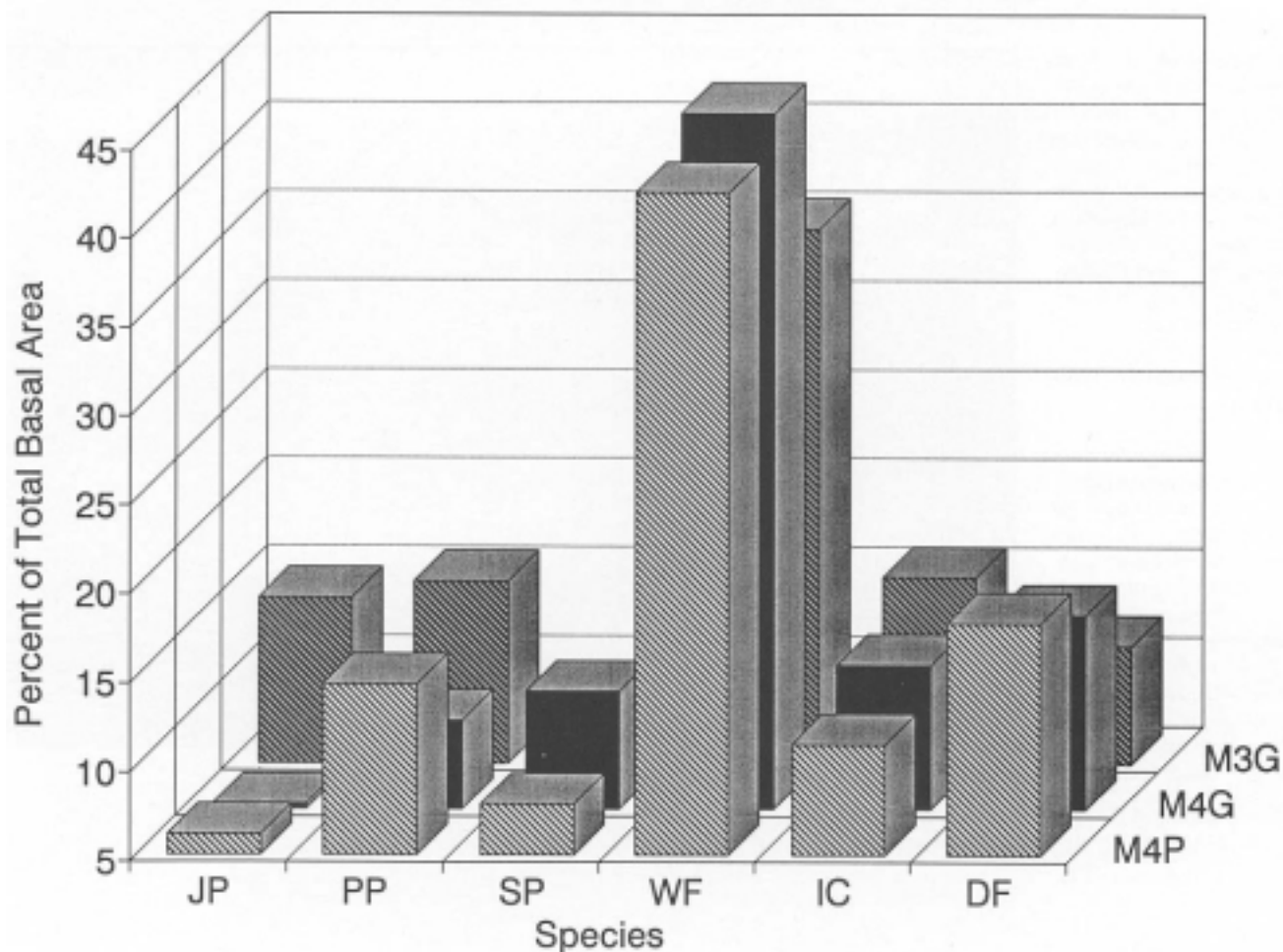


Figure 11N--Species composition (1980-1990) in the most widespread mixed-conifer strata (JP =Jeffrey pine, PP = ponderosa pine, SP = sugar pine, WF = white fir, IC = incense-cedar, and DF = Douglas-fir). For the strata labels, M = mixed-conifer forest, "3" means that the dominant tree diameter-class lies between 12 and 24 inches; "4" indicates that it lies between 24 and 40 inches. "P" indicates poor stocking--canopy closure 0-39 percent; "G" indicates good stocking--canopy closure >69 percent. These data were derived from Forest Service Region 5 inventory data.

the ponderosa pine type, have far fewer firs and a greater percentage of yellow pine. It is reasonable, however, to infer from these data that the proportion of fir (basal area or volume) has increased by perhaps 10-20 percent, while the proportion of yellow and sugar pines has decreased by a similar amount. We are surprised that this trend has not been stronger, given the preference for logging yellow and sugar pine and the expected successional patterns of the forest. The stand structure at the turn of the century was often quite open, and became more scattered subsequent to heavy logging (figs. 11P and 11Q). These open stand conditions may have favored pine regeneration and helped to produce the species composition we see today (figs. 11R and 11S). Compare figures 11P and 11Q with figures 11R and 11S to observe these changes. The trend toward the more shade-tolerant fir will be enhanced by selective removal of other species, by fire suppression, and by maintenance of the very dense stand conditions that exist in many areas of the Sierra Nevada today. The trend will, to a certain extent, be counteracted by infestations of the fir engraver beetle, to which these stands appear to be very susceptible.

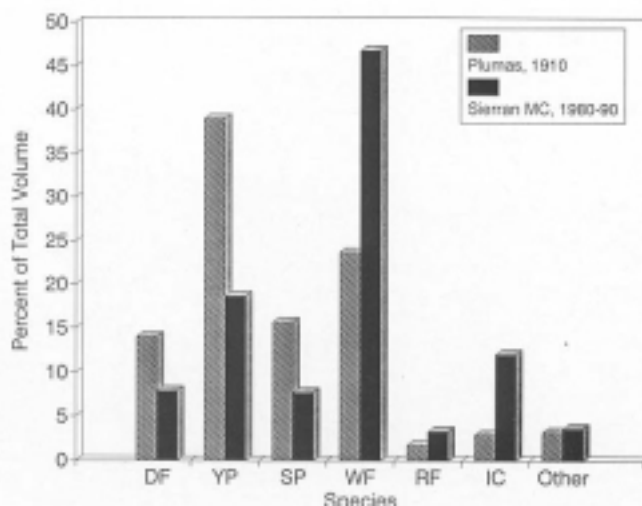


Figure 11O--Volume estimates, by species, in the Plumas National Forest in 1910 (Moore 1913) and from current inventory data. Mixed-conifer (MC) strata M3G, M4P, and M4G were combined for this analysis. See figure 11 N for species codes and a description of the timber strata classifications.

Figure 11P--Left half of two-photo historic panorama. Between 1924 and 1930, this area was owned and intensively logged by the Yosemite Lumber Company, then either sold to or exchanged with the Stanislaus National Forest. Typical of railroad logging days, about 70 percent of the timber was removed and about 30 percent left. An ample number of snags, cull logs, tops, and limbs were left scattered to decay naturally.



Location: ----Looking west from the railroad grade, 1 mile south of Camp 16, into Moss Creek Canyon, Stanislaus National Forest

Elevation:-----6,257 feet

Date: -----1930

Source: -----USDA Forest Service, Regional Photo Archives, San Francisco, CA

Photo-grapher: ---Unknown



Figure 11Q--Right half of two-photo historic panorama. This photo was labeled "old" cutting (1929) on the left background, and "new" cutting (1930) on the right foreground. Note the area left-center (arrows) where soils were intensively impacted by skidding. Today this area still has mostly brush and young black oaks (fig. 11S). Other areas, where some residual conifers were left and skidding had less impact, show a more rapid natural regeneration.

Location: --Looking northwest from the railroad grade over an unnamed tributary to Moss Creek, Stanislaus National Forest

Elevation: --6,257 feet

Date: -----1930

Source:-----USDA Forest Service, Regional Photo Archives, San Francisco, CA

Photo-grapher: -Unknown



Figure 11R-Left half of 1991 comparative photo. Today the area shown in figure 11P shows a dense mixed-conifer forest of white fir, ponderosa pine, incense-cedar, sugar pine, and scattered black oaks. This regeneration is all natural. It has been classified as owl foraging habitat.

Location: ----Same as previous historic photo (fig. 11P), but looking more to the right.

Elevation: ----6,257 feet

Date: -----December 1991

Photo-grapher: ----John S. Senser

Figure 11S-Right half of 1991 comparative photo. Arrows denote the same general areas seen in figure 11Q. Crane Flat Lookout (on the upper right peak) and the railroad grade are hidden by dense second growth. The light vegetation on the background slopes and left foreground is black oak in autumn foliage. Insect kills dominate the patch of gray conifers.

Location: ----Almost the exact perspective as figure 11Q

Elevation: ----6,257 feet

Date: -----December 1991

Photo-grapher: ----John S. Senser



Cutting History in the Sierra Nevada

The rate of volume removal, in general terms, serves as an index of the level of logging disturbance on the land. We developed a cutting history for the Sierra Nevada from 1869-1990 (fig. 11T). This was based largely on county records from 1947-1990 available from the California Department of Forestry and Fire Protection (1947-78) and the California State Board of Equalization (1979-90), and from statewide totals by species prior to 1947 (May 1953). Prior to 1947, therefore, we assumed that all volume generated by species common in the Sierra Nevada was taken only from the Sierra Nevada. That species group included ponderosa and sugar pines, incense-cedar, and white fir. Volume estimates from the early period were probably inaccurate for several reasons. The assumption that the state's entire harvest of sugar and ponderosa pine came from the Sierra Nevada would tend to bias these estimates high. On the other hand, the volume estimates do not accurately account for fuelwood, shake production, and extensive wastage left in the woods (May 1953, Laudenslayer and Darr 1990); all of those factors would tend to bias the volume estimate low. We do not know the extent to which these contrasting biases would tend to offset each other.

By 1913, logging contracts were similar to those used today by the FS. Maximum stump height was 18 inches, and the merchantable top was set at 8-10 inches in diameter. The planned rotation period in the Plumas NF was set at 200 years, and the maximum cut was set at 132 MMBF (Moore 1913). Local use of wood for fuel apparently declined in the early part of the twentieth century. The proposed cut for the Stanislaus NF in 1912 allocated only 164 MBF for "free use" (Graves 1912). Because

of these restrictions, the market volume after 1910 probably reflected the actual cut reasonably well.

Logging in the Sierra Nevada increased until about 1950, with a significant dip during the Great Depression. Logging levels declined slightly after 1950, remained fairly constant until the 1982 recession, then increased again to the point that 1990 levels were near the historic peak. This pattern differs from that in north-coastal California, where the rate of logging increased dramatically after World War II and then declined (fig. 11U).

Prescriptions used to cut timber in the Sierra Nevada have also differed from those of the coast. Logging in the Sierra Nevada prior to the 1980s seldom used a clearcutting prescription. If a tree had no market value, it was simply left standing. Even through the 1970s, when a policy shift toward clearcutting occurred, it accounted for most of the volume taken only from 1983 to 1987 (fig. 11V). By the end of the decade, cutting was increasingly concentrated in salvage operations (fig. 11W). Because early cutting, even the relatively heavy cutting done on private lands, seldom involved clearcuts (figs. 11P-11S), disturbance patterns in the Sierra Nevada are very different today from those that have characterized the habitat of the northern spotted owl. In most of the lands occupied by the northern spotted owl, heavy clearcutting in recent years has generated a patchwork of uncut "old growth" and new plantations—a spatially heterogeneous system. In the Sierra Nevada, virtually all stands have been entered and trees have been selectively removed. Both private (Laudenslayer and Darr 1990) and public owners tended to apply similar harvest rules on large blocks of land. Because tree removal has targeted larger stems, and because these large trees appear to have been unevenly distributed on the landscape, forming groves (Fitch 1900b), it is likely that their removal caused a decrease rather than an increase in landscape-level forest heterogeneity.

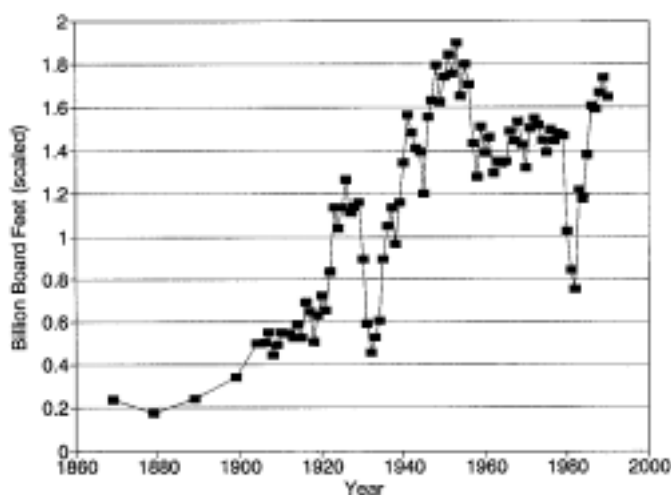


Figure 11T—Market volume of timber from the Sierra Nevada. Volume before 1947 was based on data supplied by May (1953); volumes for 1947-1990 were based on records kept by the California Department of Forestry and Fire Protection (1947-78) and the California State Board of Equalization (1979-90).

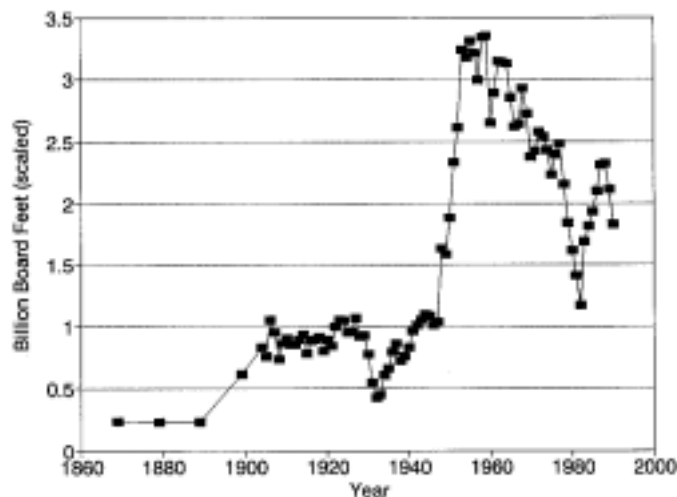


Figure 11U—Market volume of timber from California's North Coast. Volumes were derived from the same sources as those in figure 11T. Volume before 1947 was based on state-wide totals, assuming that all redwood and Douglas-fir came from coastal forests.

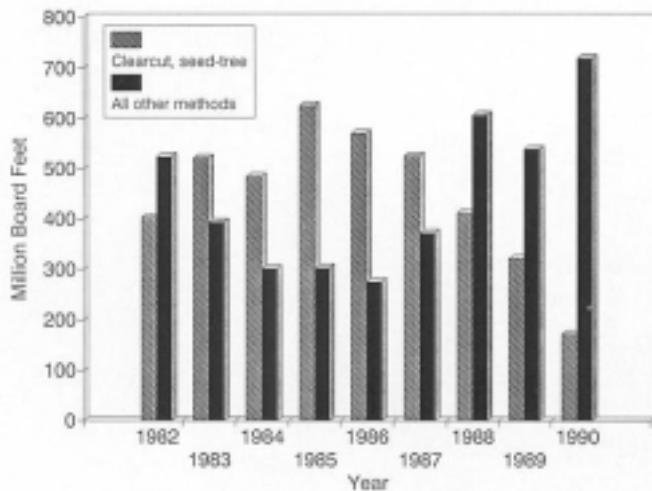


Figure 11V—Logging patterns by prescription for National Forests in the Sierra Nevada, 1982-1990 (from sold-sale records, Forest Service Region 5).

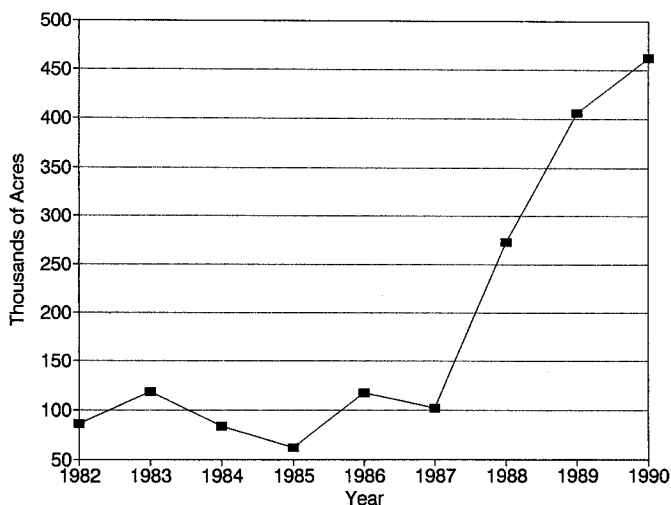


Figure 11W—Acres entered for sanitation-salvage logging on National Forests in the Sierra Nevada, 1982-1990 (from sold-sale records, Forest Service Region 5).

Discussion of Sierran Forest Conditions

Because grazing and burning occurred simultaneously and in the same areas, we cannot separate their effects. As Sudworth (1900a) noted, however, destruction of a perennial grass community did not likely result from fire alone. The ability of intense grazing to interfere with regeneration is well known, and was documented by both Sudworth (1900a) and Leiberg (1902). The bare soils prevalent at the turn of the century probably provided an excellent seed bed for abundant tree regeneration, a process discussed by both Sudworth and Leiberg and supported by

Vankat (1970). The pattern of burning by Native Americans probably differed from that of sheep herders, because their goals differed. Both groups sought short-term and long-term alteration of the forest. Native Americans probably used fire to herd game and to improve wild food crops (Vankat 1970, Lewis 1973, Anderson 1991). Sheep herders, on the other hand, sought to improve grazing and to remove obstacles to the passage of sheep.

We do not expect, therefore, that the forest described at the turn of the century was in any sense pristine. Although most current FS lands were uncut then, the forest floor and regeneration structure were impacted repeatedly by intense grazing. Moreover, even if that forest were relatively untouched, it would not necessarily have looked like a pristine forest that would exist today. Many of the trees in older forests in 1900 were established in the 1600s or before, and grew during a period characterized by extended droughts. The periods from 1750 to 1820 and from 1860 to 1880 were very dry in California (fig. 11X) (Fritts and Gordon 1980, Fritts 1991). The forest that Sudworth (1900a) described was largely established before those droughts began.

Drought, combined with grazing and fire, created a forest dominated by very large, old trees and with very little ground cover. We believe the forests described at the turn of this century were less heterogeneous than the forests influenced by aboriginal and lightning fires. The latter were probably typified by heavily stocked areas on more mesic sites, more trees in intermediate size-classes, and more large-diameter logs and other woody materials on the ground (sheep herders specifically targeted large woody debris for burning).

Cutting in the Sierra Nevada increased steadily over time, reaching a peak after World War II. Since then, with the exception of the 1982 recession, cutting has remained at fairly constant levels. The pattern of partial cutting that typically removed only the largest and oldest trees from a stand, coupled with abundant regeneration that followed removal of sheep from the forests and the initiation of fire suppression, resulted in a shift in diameter distribution of trees between the forests of 1900 and 1990. Available evidence suggests that species composition, measured as basal area or volume, has not yet been substantially altered by these practices, but observation suggests that much of the current regeneration consists of true fir and incense-cedar.

The mixed-conifer zone of the Sierra Nevada, therefore, has few or no stands remaining that can be described as natural or pristine. To various degrees, the forest system has been changed from one dominated by large, old, widely spaced trees to one characterized by dense, fairly even-aged stands in which most of the larger trees are 80-100 years old. This forest appears to be unstable. It is highly susceptible to drought-induced mortality, as competition for water weakens trees on drier sites. It is impacted by massive bark beetle infestations. And it is very flammable (Chapter 12). Its trajectory into the future is largely unknown, but stand structure can be expected to change markedly over the next 100 years.

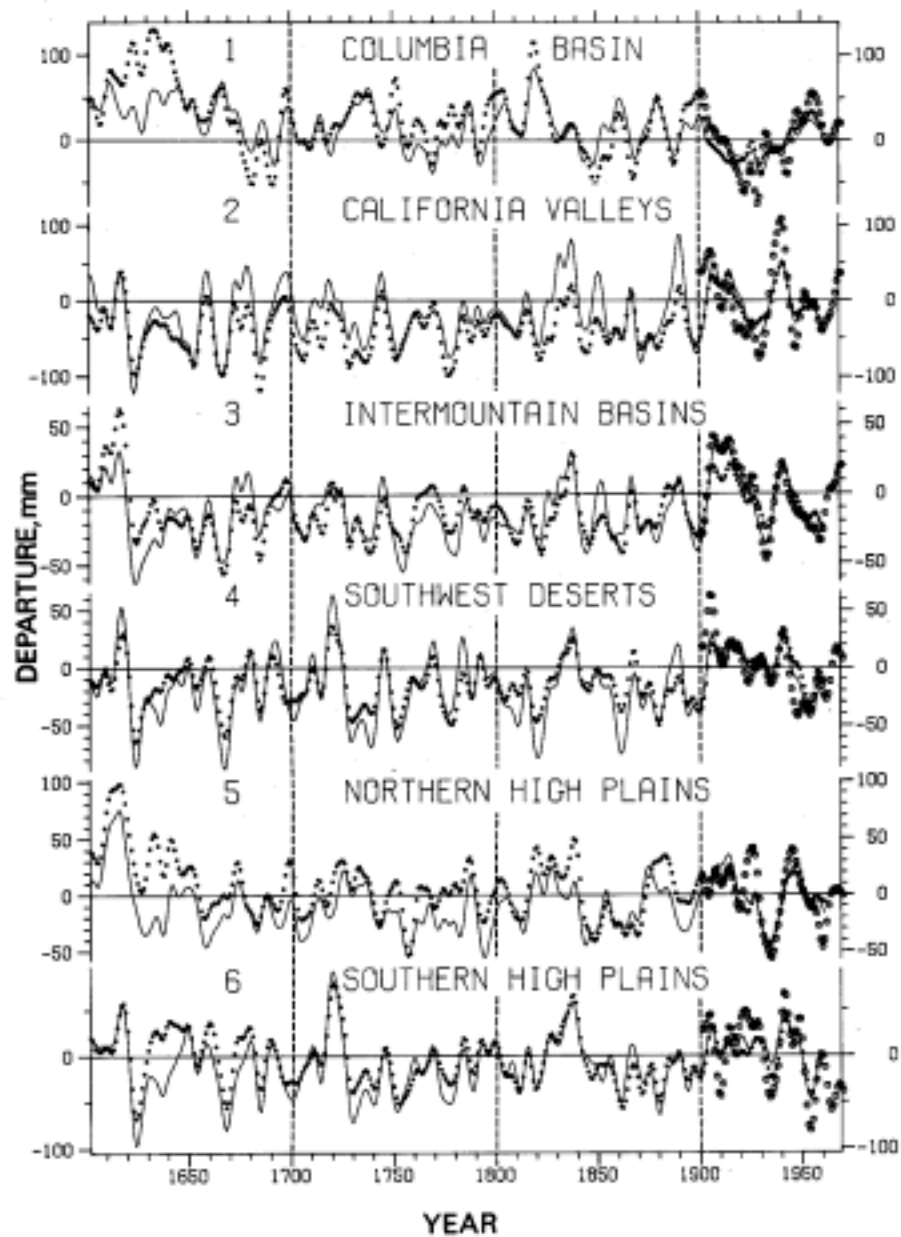


Figure 11X—Patterns of precipitation in the western United States from 1600 to 1970 (Fritts 1991, figure 7.4), based on tree-ring analyses. The solid line is based on data from the western United States, the small dots are based on data from a larger grid covering the entire United States, and the large dots in the twentieth century are based on measured precipitation data.

Southern California Forests at the Turn of the Century

The Forest Reserve system in southern California consisted in 1897 of the San Bernardino, San Gabriel, San Jacinto, and Trabuco Canyon reserves. Today, the San Bernardino NF includes parts of the San Bernardino, San Jacinto, and San Gabriel (eastern edge) reserves. The Angeles NF contains most of the San Gabriel Reserve, and the Trabuco Canyon Reserve, which covered a portion of the Santa Ana Mountains, has been largely incorporated into the Cleveland NF. Leiberg (1899x, 1899b, 1899c) surveyed the first three reserves in 1897, and Bamard (1900) resurveyed the 30-minute San Jacinto Quadrangle in 1900 and provided a map similar to those created by Sudworth and Leiberg for the Sierra Nevada.

Surveys included acreage outside of current FS boundaries. The San Bernardino and San Jacinto reserves, for instance, included many areas that are now privately owned, managed by the Bureau of Land Management, or incorporated into Indian Reservations. For this reason, total acreages are larger and the proportions of reserves listed in a nonforested condition are greater than would be indicated by current inventories. Most of the timbered acreage has, however, been retained by the FS, so statistics associated with forested lands at the turn of the century can be compared with those derived from modern inventories (table 11D). Given the differences in classification methods, the forested acreage statistics are remarkably similar.

Table 11D-*Acres of forested lands in southern California, as estimated in 1899 and in 1987 and 1988.*

Reserve	Year of estimate	
	1899 ¹	1987 and 1988 ²
San Gabriel		
Forested	100,000	145,438
Productive ³	25,000	26,687
Total acres	650,000	651,874
San Bernardino and San Jacinto		
Forested	441,000	389,892
Productive ³	122,500	160,631
Total acres	1,474,000	649,900

¹ San Bernardino Reserve (Leiberg 1899a); San Jacinto Reserve (Leiberg 1899b); San Gabriel Reserve (Leiberg 1899c). Leiberg did not know the exact boundaries of the reserves.

² Data from the Angeles National Forest correspond to the San Gabriel Reserve (USDA Forest Service 1987); data from the San Bernardino National Forest correspond to the San Bernardino and San Jacinto Reserves (USDA Forest Service 1988).

³ Productive lands were defined as Class 1 lands (both accessible and capable of producing timber) by Leiberg, and lands capable of producing >20 cubic feet/acre/year for estimates by the USDA Forest Service (1987).

Species Composition in 1897

Leiberg (1899a, p. 356) estimated species composition in the three reserves that he surveyed (figs. 11Y, 11Z, and 11AA). The methods used to obtain these data were not stated in detail, but Leiberg wrote: "These estimates were based on the customary method of scaling standing timber," suggesting that his estimates were based, at least in part, on measured plot data. The survey effort in 1897, however, appears to have been less intense than in 1900 or 1902. Because less time was spent in the area, the extent to which vegetation patterns were derived from inference, instead of direct observation, would increase. Therefore, tree species that are heterogeneously distributed-especially minor species-easily could be either over- or under-represented.

The general pattern in 1900 was one of low-elevation forests dominated by either ponderosa pine or bigcone Douglas-fir, with white fir entering as a major stand component above 6,000 feet. Lodgepole pine was present in quantities only above 8,500 feet.

Nonaboriginal Human Disturbance by 1900

Logging occurred in the San Bernardino Mountains as early as 1865 (Leiberg 1899b), but was limited in extent. By 1897, logging was still limited to an area north of San Bernardino; it did not extend appreciably into the eastern or northern portions of the San Bernardino Reserve. Logged areas mapped in the San Jacinto Reserve were very small, lying primarily in the upper basin of the North Fork of the San Jacinto River and in an area adjacent to the town of Idyllwild, in the Strawberry Creek drainage. The total area logged in the San Jacinto covered "not more than 1 square mile" (Barnard 1900, p. 575). No extensive timber cutting had occurred in the San Gabriel Reserve by the end of last century (Leiberg 1899c).

Little evidence exists of extensive grazing in the forests of southern California at the turn of the century. Leiberg (1899b, p. 360) estimated that no more than "a few hundred head of stock" were regularly pastured in the San Bernardino Reserve, although several thousand head were grazed there in 1897 because of a drought. Leiberg did not state exactly what a "head of stock" was but, judging from his comments on the San Jacinto Reserve, he probably meant cattle. In the San Jacinto, he stated that "An unknown number of cattle and horses-probably 1,500-2,000 head-graze in the reserve" (Leiberg 1899a, p. 354). Grazing was not discussed for the San Gabriel Reserve. There is, however, evidence of extensive grazing by sheep in the San Bernardino and San Jacinto Mountains in the late 1800s. Minnich (1988) reported that sheep grazing occurred over much of the San Bernardino Mountains during the period from 1860 to 1898, to such an extent that many areas were grazed to a bare-earth condition. In particular, as many as 30,000 sheep were grazed in the area around Little Bear Valley and an additional 30,000 were grazed in the Santa Ana River drainage (Minnich 1988, p. 39-40). As with reports of grazing in the Sierra Nevada, the extent of destruction that resulted from sheep grazing may have been exaggerated because of the biases of early observers.

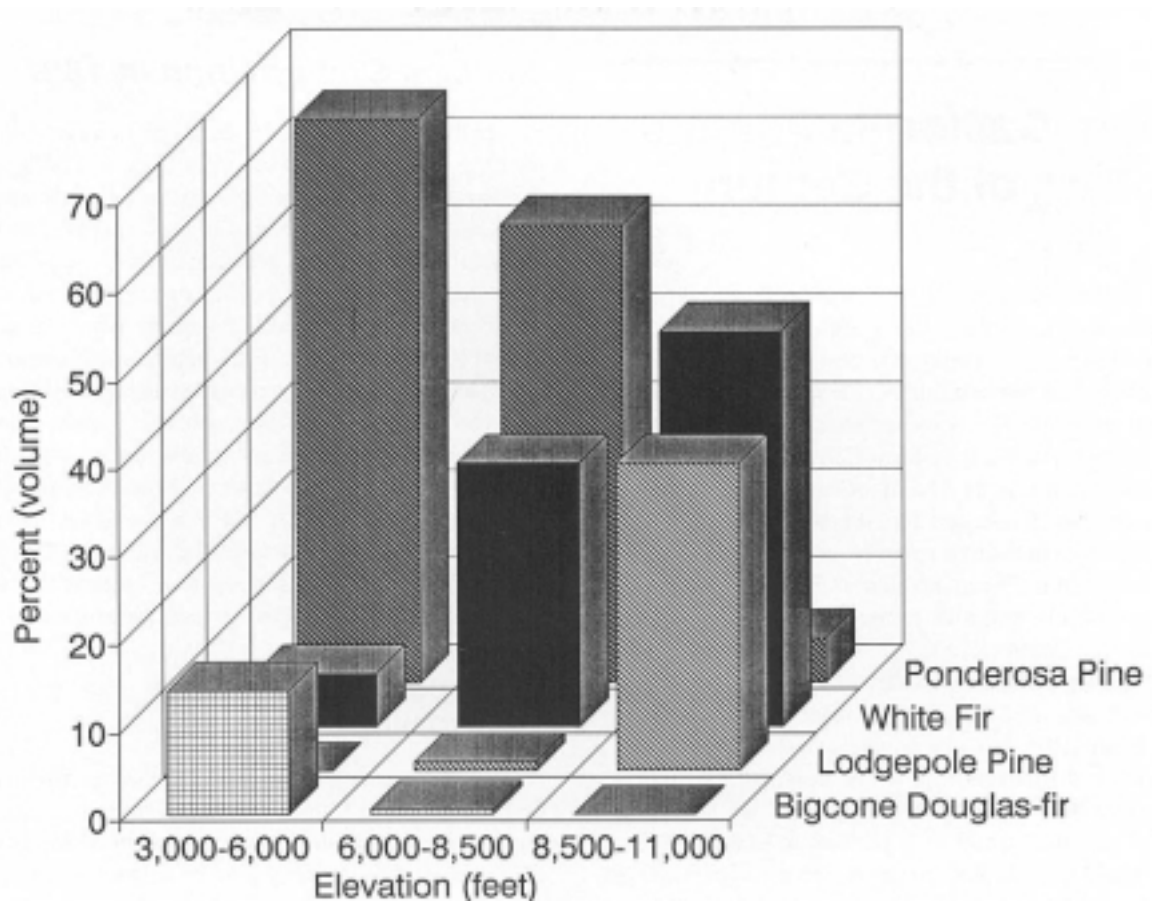


Figure 11Y--Species composition in the San Bernardino Forest Reserve in 1897 (Leiberg 1899b). Hardwood species, with the exception of oaks, were not used when Leiberg calculated percent contribution, by species.

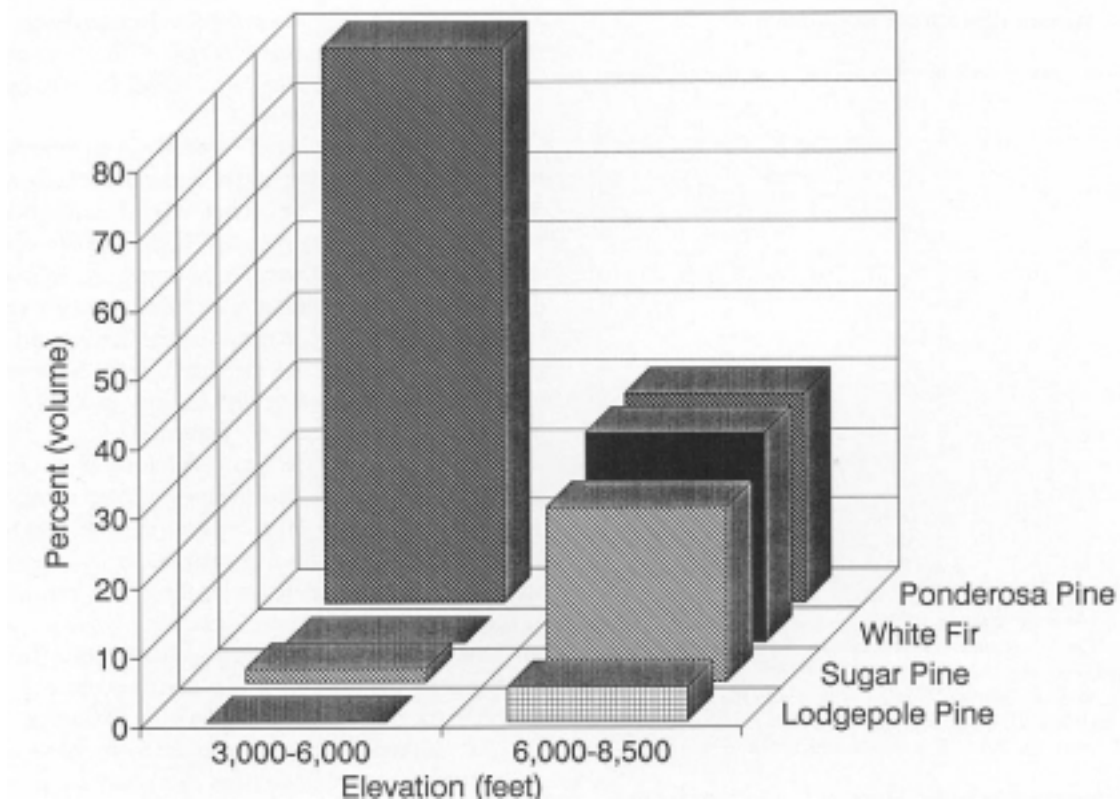


Figure 11Z--Species composition in the San Jacinto Forest Reserve in 1897 (Leiberg 1899a). Hardwood species, with the exception of oaks, were not used when Leiberg calculated percent contribution, by species.

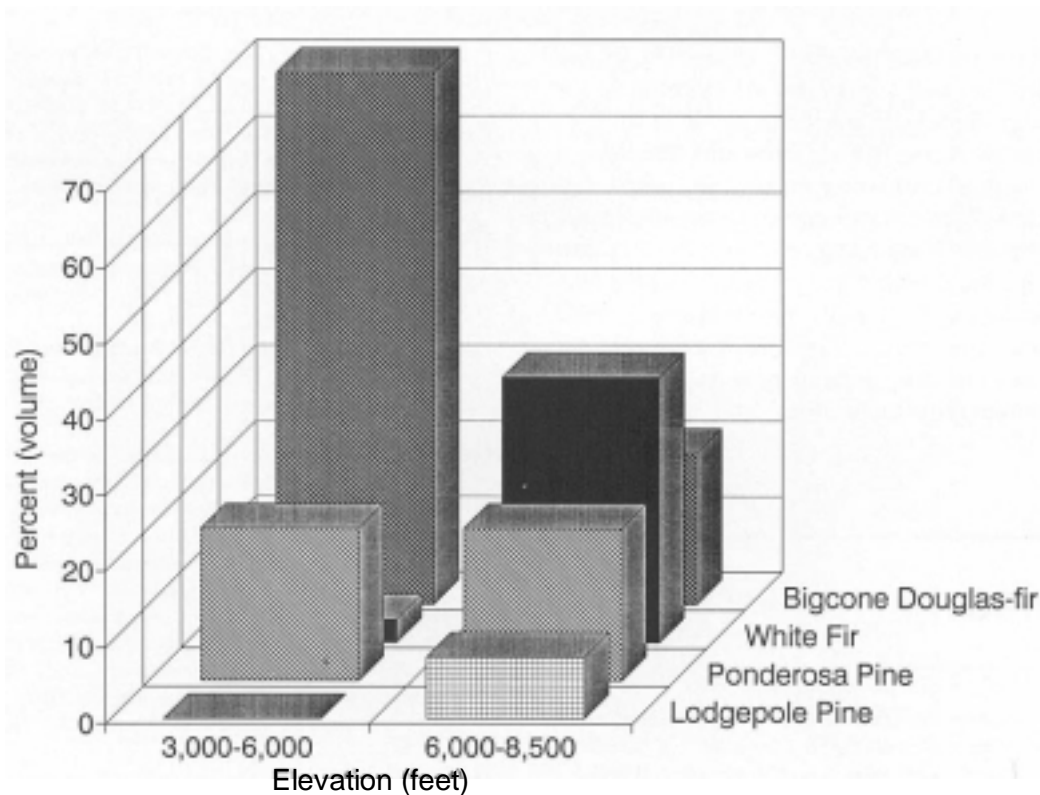


Figure 11AA--Species composition in the San Gabriel Forest Reserve in 1897 (Leiberg 1899c). Hardwood species, with the exception of oaks, were not used when Leiberg calculated percent contribution, by species.

The San Gabriel Mountains are extremely steep, so they were not logged or grazed extensively. They were (and still are) very susceptible to burning, however. In particular Leiberg (1897c, p. 369) noted the destruction of bigcone Douglas-fir stands by fire:

Among the non-commercial species of trees the bigcone fir has suffered the most. Large tracts once covered by it have been totally laid waste and much of what remains is partially burned or scarred... It is not improbable that a considerable

portion of the areas now grown up in brush were in the past covered with a forest of bigcone fir. The very numerous small groves and individual trees of the species rising from the sea of chaparral would lead one to infer that they represent remnants of a more extensive forest. It is also noteworthy that the worst-burnt areas in the three reserves examined are to be found in the San Gabriel Reserve in the region of the most extensive mining operations.

Cutting History in Southern California

We have reconstructed the history of the removal of timber volume from San Bernardino and Los Angeles counties. Volume removed from 1947 to 1990 was based on data from the California Department of Forestry and Fire Protection (1947-78) and the California State Board of Equalization (1979-90). The San Bernardino NF had a very active timber program after World War II, cutting 27.4 MMBF in 1963 alone (fig. 11AB). Altogether, 362.3 MMBF of timber have been removed from these counties since 1947.

Discussion

Changes induced by nonaboriginal man in the southern California forests appear to have been slight by the turn of the century. Some logging and grazing had occurred by then. Leiberg described fires as being widespread but, with the exception of bigcone Douglas-fir stands in the San Gabriel Mountains, he apparently did not believe that forest structure or the balance

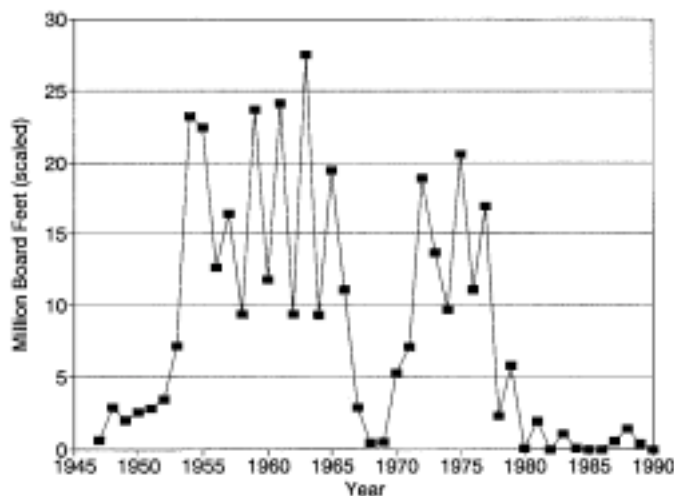


Figure 11AB--Logging intensity in San Bernardino and Los Angeles Counties, 1947-1990 (California Department of Forestry and Fire Protection 1947-78, California State Board of Equalization 1979-90).

between brush and conifer forests was being changed by the fire patterns. Leiberg had no way to ascertain the extent to which burning patterns at that time were unnatural.

In the period after World War II, forest structures would have been significantly altered where timber was logged. Because logging would have been concentrated on sites with higher productivity, it undoubtedly impacted spotted owl habitat, though we cannot determine the extent of that impact. In general, the proportion of the area supporting conifer forests appears to have been reasonably static over the last 90 years. No evidence supports the idea of either spreading or shrinking acreage of chaparral in southern California over that period.

References

- Anderson, Kat. 1991. From tillage to table: the digging and burning of Indian potato plants among California Indian tribes as examples of sustainable horticulture. In: Blackburn, Tom; Anderson, Kat; symposia organizers. Native Americans as environmental managers. The seventh annual California Indian Conference. Rohnert Park, CA: Sonoma State University; 12 p.
- Ayres, R. W. 1958. History of timber management in the California National Forests, 1850 to 1937. Washington, DC: U.S. Department of Agriculture, Forest Service; 86 p.
- Barnard, E. C. 1900. San Jacinto Quadrangle, California. In: Annual Reports of the Department of the Interior, 21st Annual Report of the U.S. Geological Survey, Part 5. Washington, DC: Government Printing Office; 575.
- Bohakel, Charles A. 1968. A history of the Empire Mine at Grass Valley. Grass Valley, CA: Nevada County Historical Society; 24 p.
- California Department of Forestry and Fire Protection. 1947-78. Production of California timber operators. State forest notes published annually. Sacramento: California Department of Forestry and Fire Protection.
- California State Board of Equalization. 1979-90. California timber harvest by county. Annual report. Sacramento: California State Board of Equalization, Timber Tax Division.
- Clark, William B. 1966. Economic mineral deposits in the Sierra Nevada. In: Geology of Northern California. San Francisco: Bulletin 190, California Division of Mines and Geology; 209-216.
- Ewing, Robert A.; Tosta, Nancy; Tuazon, Raul; Huntsinger, Lynn; Marose, Robin; Nielson, Ken; Motroni, Robert; Turan, Sarah. 1988. Rangelands: growing conflict over changing uses. Sacramento: Forest and Rangeland Resources Assessment Program, California Department of Forestry and Fire Protection; 348 p.
- Fitch, C. H. 1900a. Sonora Quadrangle, California. In: Annual Reports of the Department of the Interior, 21st Annual Report of the U.S. Geological Survey, Part 5. Washington, DC: Government Printing Office; 569-571.
- Fitch, C. H. 1900b. Yosemite Quadrangle, California. In: Annual Reports of the Department of the Interior, 21st Annual Report of the U.S. Geological Survey, Part 5. Washington, DC: Government Printing Office; 571-574.
- Fritts, Harold C. 1991. Reconstructing large-scale climatic patterns from tree-ring data: diagnostic analysis. Tucson, AZ: University of Arizona Press; 286 p.
- Fritts, Harold C.; Gordon Geoffrey A. 1980. Annual precipitation for California since 1600 reconstructed from western North American tree rings. Agreement No. B53367. Sacramento: California Department of Water Resources; 45 p.
- Graves, Henry S. 1912. Letter to the Secretary of Agriculture. Washington, DC: U.S. Department of Agriculture; 3 p.
- Laudenslayer, William F.; Darr, Herman H. 1990. Historical effects of logging on the forests of the Cascade and Sierra Nevada ranges of California. Transactions of the Western Section of the Wildlife Society 26:12-23.
- Leiberg, John B. 1899a. San Jacinto Forest Reserve. Preliminary report. In: Annual Reports of the Department of the Interior, 19th Annual Report of the U.S. Geological Survey, Part 5. Washington, DC: Government Printing Office; 351-357.
- Leiberg, John B. 1899b. San Bernardino Forest Reserve. Preliminary report. In: Annual Reports of the Department of the Interior, 19th Annual Report of the U.S. Geological Survey, Part 5. Washington, DC: Government Printing Office; 359-366.
- Leiberg, John B. 1899c. San Gabriel Forest Reserve. Preliminary report. In: Annual Reports of the Department of the Interior, 19th Annual Report of the U.S. Geological Survey, Part 5. Washington, DC: Government Printing Office; 367-371.
- Leiberg, John B. 1902. Forest conditions in the northern Sierra Nevada, California. Professional paper No. 8, Series H, Forestry 5. Washington, DC: U.S. Department of the Interior, U.S. Geological Survey; 194 p.
- Lewis, Henry T. 1973. Patterns of Indian burning in California: ecology and ethnohistory. Ramona, CA: Ballena Press Anthropological Papers No. 1; 101 p.
- Marshall, C. H. 1900. Mount Lyell Quadrangle, California. In: Annual Reports of the Department of the Interior, 21st Annual Report of the U.S. Geological Survey, Part 5. Washington, DC: Government Printing Office; 574-576.
- May, R. H. 1953. A century of lumber production in California and Nevada. Forest Survey Release No. 20. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 33 p.
- McKeon, Owen F. 1984. The railroads and steamers of Lake Tahoe. The Western Railroader. San Mateo, CA: Francis Guido, Publisher; 22 p.
- Minnich, Richard A. 1988. The biogeography of fire in the San Bernardino Mountains of California: a historical study. Berkeley, CA: Univ. of California Press. Univ. of California Publications in Geography 28:1-160.
- Moore, Barrington. 1913. Forest plan, Plumas National Forest. Quincy, CA: Forest Service, U.S. Department of Agriculture; 33 p.
- Palmer, Lex. 1992. Metal mining on California's National Forests: a portrait of societal demands, technology, and multiple use from prehistoric times to World War II. Unpublished draft supplied by author; 195 p.
- Ratliff, Raymond D. 1985. Meadows of the Sierra Nevada of California: state of knowledge. Gen. Tech. Rep. PSW-84. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 52 p.
- Sudworth, George B. 1900a. Stanislaus and Lake Tahoe Forest Reserves, California, and adjacent territory. In: Annual Reports of the Department of the Interior, 21st Annual Report of the U.S. Geological Survey, Part 5. Washington, DC: Government Printing Office; 505-561.
- Sudworth, G. B. 1900b. Notes on the regions in the Sierra Forest Reserve, 1898-1900. Unpublished draft supplied by author; 141 p.
- U.S. Department of Agriculture, Forest Service. 1987. Land and resource management plan. Angeles National Forest. San Francisco, CA: USDA Forest Service, Pacific Southwest Region; 181 p.
- U.S. Department of Agriculture, Forest Service. 1988. Land and resource management plan. San Bernardino National Forest. San Francisco, CA: USDA Forest Service, Pacific Southwest Region; 315 p.
- Vankat, John Lyman. 1970. Vegetation change in the Sequoia National Park, California. Davis: Univ. of California; 197 p. Dissertation.